or a TMR structure.

In the step of FIG.3A, a resist pattern 120 is formed on the ferromagnetic film 104 by applying a resist film, followed by a photolithographic patterning process.

Next, in the step of FIG.3B, a layer of a high-coercive magnetic material having a large coercive force, such as a hard magnetic material, an example of which may be a CoCrPt alloy, or an anti-ferromagnetic material such as a PdPtMn alloy, is deposited on the structure of FIG.3A by a sputtering process while using the resist pattern 120 as a mask. As a result, high-coercive magnetic regions 107A and 107B are formed on the magneto-resistive film 104 at both lateral sides of the resist pattern 120.

Next, in the step of FIG.3C, the resist pattern 120 is subjected to a shrinking process, which may be any of a heat-treatment process, chilling process, oxygen-ashing process, a drying process, or other suitable chemical and/or physical processes, wherein the resist pattern 120 undergoes shrinking as a result of such a process and there are formed gaps RSA and RSB between the shrunken resist pattern 120 and the high-coercive regions 107A and 107B.

Next, in the step of FIG.3D, an insulating film 109 of Al_2O_3 or SiO_2 is deposited on the structure of FIG.3C such that the insulating film 109 makes a contact with the ferromagnetic free layer at the top part of the magneto-resistive film 104 in the regions corresponding to the foregoing gaps RSA and RSB.

Next, in the step of FIG.3E, a planarizing resist film 125 is applied on the structure of FIG.3D for planarization and the planarized structure thus obtained is subjected to an etching process so as to remove the insulating film 109 forming a cap on the shrunken resist pattern 120. After the removal of the cap film, the resist pattern 120 is removed by

dissolution into a solvent or a suitable ashing process, and the structure shown in FIG.3F is obtained in which the surface of the ferromagnetic free layer 105 is exposed between the insulating films 109A and 109B respectively covering the high-coercive patterns 107A and 107B.

In the event the resist pattern 120 is in the state suitable for removal by dissolution into solvent or ashing process in the step of FIG.3D, the fabrication process of the magnetic head may jump to the step of FIG.3F directly from the step of FIG.3D.

In the state of FIG.3F, it should be noted that the insulating film 109A covers the part of the ferromagnetic free layer 105 in correspondence to the gap RSA and the insulating film 109B covers the part of the ferromagnetic free layer 105 in correspondence to the gap RSB.

Next, in the step of FIG.3G, a top electrode layer 110 of typically Pt is deposited on the structure of FIG.3F by a sputtering process, wherein the Pt electrode 110 thus formed makes a contact with the part of the ferromagnetic free layer 105 exposed between the insulating film 109A on the high-coercive region 107A and the insulating film 109B covering the high-coercive region 107B.

After the step of FIG.3G, the layered structure on the substrate 101 is patterned in the step of FIG.3H by a suitable process such as an ion milling process, and interconnections (not shown) are provided to the top electrode layer 110 and the bottom electrode 103.

In the magnetic head of FIG.3H thus obtained, it should be noted that the high-coercive regions 107A and 107B cause a pinning of magnetization in the ferromagnetic free layer 105 in correspondence to the part located right underneath the regions 107A and 107B, and the problem of formation of multiple domain

structure in the magneto-resistive film 104 and associated problem of formation of Barkhausen noise are effectively eliminated. Thus, by measuring the resistance of the magneto-resistive film 104 by way of measurement of the sensing current caused to flow from the top electrode 110 to the bottom electrode 103, it is possible to detect an external magnetic field produced by a magnetic dot on a magnetic disk with high sensitivity.

According to the present embodiment, the magneto-resistive head of FIG.3H has an advantageous feature in that injection of the sensing current is made selectively into the magneto-resistive film in correspondence to the region located inside the part covered by the insulating films 109A and 109B. Thus, by choosing the thickness of the insulating film 109, and hence the thickness of the insulating films 109A and 109B, appropriately in the step of FIG.3D in correspondence to the thickness or width of the magnetically pinned region caused by the high-coercive regions 107A and 107B, it is possible to avoid injection of the sensing current into the dead region in which the pinning of the magnetization is caused. Thereby, the sensing current picks up the change of resistance of the magneto-resistive film 104 with high sensitivity.

As the same resist pattern 120 is used in the step of FIG.3B when forming the high-coercive regions 107A and 107B and in the step of FIG.3D for forming the insulating patterns 109A and 109B, there occurs no problem of positional offset for the insulating patterns 109A and 109B with respect to the high-coercive regions 107A and 107B, and the structure of FIG.3H is obtained with high reproducibility and high yield, even in such a case the separation between the high-coercive regions 107A and 107B is narrowed in correspondence to increase of recording density on the

magnetic disk.

In FIG.3H, it should be noted that the region designated by KSH represents an optical core region or a geometrical core region structurally defined with respect to a magnetic track on the magnetic disk, wherein the present invention enables to form the magneto-resistive head such that the optical core region substantially coincides with the actual core region in which actual magnetic detection of a magnetic track takes place.

[SECOND EMBODIMENT]

FIGS.4A - 4F show the fabrication process of a magneto-resistive head 200 of the overlaid type according to a second embodiment of the present invention.

Referring to FIG.4A, a magneto-resistive film such as a GMR film or a TMR film similarly to the magneto-resistive film 104 is formed on a substrate 201, and a resist pattern 205 is formed on the magneto-resistive film. Further, the magneto-resistive film is subjected to a patterning process while using the resist pattern 205 as a mask, and there is formed a magneto-resistive pattern 204 underneath the resist pattern 205 in conformity therewith.

Next, in the step of FIG.4B, a layer of a high-coercive material such as a ferromagnetic layer of CoCrPt, or an anti-ferromagnetic layer of PdPtMn, is deposited on the structure of FIG.4A while using the same resist pattern 205 as a mask, and there are formed high-coercive regions 202A and 202B at both lateral sides of the magneto-resistive pattern 204 in self-alignment with the resist pattern 205, and hence with the magneto-resistive pattern 204.

Next, in the step of FIG.4C, the resist pattern 205 is subjected to a shrinking process similarly to the step of FIG.3C, and there are formed

regions RSA and RSB at both lateral edges of the magneto-resistive pattern 204 in which the surface of the magneto-resistive pattern 204 is exposed.

Next, in the step of FIG.4D, a conductive layer such as Pt is deposited on the structure of FIG.4C while using the shrunken resist pattern 205 as a mask, to form electrodes 203A and 203B respectively on the high-coercive regions 202A and 202B, wherein the electrode 203A has a tip-end part 203A-a extending over the magneto-resistive pattern 204 toward the opposing electrode 203B beyond the boundary between the high-coercive region 202A and the magneto-resistive pattern 204. Similarly, the electrode 203B has a tip-end part 203B-b extending over the magneto-resistive pattern 204 toward the opposing electrode 203A beyond the boundary between the high-coercive region 202B and the magneto-resistive pattern 204, as represented in FIG.4E. It should be noted that the structure of FIG.4E represents the state in which the structure of FIG.4D is patterned on the substrate 201 by a suitable process such as an ion milling process.

Further, interconnection patterns 206A and 206B are provided on the electrodes 203A and 203B in the step of FIG.4F.

According to the present invention, it becomes possible to reduce the deviation between the geometrical or optical core width, defined as the distance between the very tip end of the tip-end region 203A-a and the very tip end of the tip-end region 203B-b, and the effective or electrical core width in the magneto-resistive head 200, by employing a self-alignment process that uses the shrunken resist pattern 205 for controlling the protruding distance of the tip-end parts 203A-a and 203B-b of the electrodes 203A and 203B. As a result of the use of the self-alignment process as explained with reference to FIGS.4D and 4E, it becomes possible to reduce the

protruding distance LPA or LPB (see FIG.4F) of the tip-end part 203A-a or 203B-b of the electrode 203A or 203B beyond the high-coercive region 202A or 202B, to be 0.25 μm or less. Thereby, the injection of the sensing current is caused only from the very tip end of the protruding tip-end part 203A-a or 203B-b while successfully avoiding unwanted injection of the sensing current from the remaining part of the tip-end part 203A-a or 203B-b protruding beyond the dead region. Thereby, the sensitivity of magnetic signals from a narrow magnetic track is improved.

In the present embodiment, it should be noted that the protruding distance LPA or LPB can be controlled as desired by controlling the amount of shrinkage of the resist pattern 205 in the step of FIG.4C.

As the shrinkage of the resist pattern 205 is caused symmetrically, the present embodiment successfully avoids the problem of lateral deviation of the electrodes 203A and 203B, and hence the tip-end regions 203A-a and 203B-b, with respect to the high-coercive regions 202A and 202B.

FIG.5 shows the relationship between the effective core width TW (see FIG.1B) and the protruding distance LPA or LPB of the tip-end part 203A-a or 203B-b of the electrodes 203A or 203B for the magneto-resistive head 200 of FIG.4H.

Referring to FIG.5, it can be seen that the effective core width TW starts to decrease rapidly when the protruding distance LPA or LPB is decreased below about 0.25μm. The magnetic head 200 of the present embodiment can easily realize the protruding distance of below about 0.25μm, by controlling the shrinkage of the resist pattern 205 in the step of FIG.4C.

[THIRD EMBODIMENT]

FIG.6 shows the construction of a magnetic disk drive 300 according to a third embodiment of the present invention, wherein the magnetic disk drive 300 uses a magnetic head of any of the preceding embodiments.

Referring to FIG.6, the magnetic disk drive 300 includes a rotating magnetic disk 301 and a magnetic head 100 held on an end of an arm scans over the surface of the rotating magnetic disk 301.

By using the magnetic head 100 of the first embodiment or the magnetic head 200 of the second embodiment, it becomes possible to read information at high speed and high resolution even in the case the magnetic disk 301 is recorded with information with high density and the track width thereon is reduced accordingly.

Further, the present invention is not limited to the embodiments described heretofore, but various variations and modifications may made without departing from the scope of the invention.